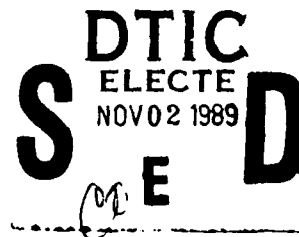SRL-0020-TM

AR-005-450

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION
SALISBURY

SURVEILLANCE RESEARCH LABORATORY

SOUTH AUSTRALIA

TECHNICAL MEMORANDUM

SRL-0020-TM

**EVALUATION OF A SIMPLE ALGORITHM FOR ESTIMATING INFRARED SIGNATURES FROM
MULTI-PIXEL TO SUB-PIXEL TARGETS APPLIED TO AGA THERMOVISION IMAGERY**

G.W. McQUISTAN

DTIC
ELECTE
NOV 0 2 1989
S E D

Approved for Public Release

MAY 1989

89 11 01 056

AR-005-450

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

SURVEILLANCE RESEARCH LABORATORY

TECHNICAL MEMORANDUM

SRL-0020-TM

EVALUATION OF A SIMPLE ALGORITHM FOR ESTIMATING INFRARED SIGNATURES FROM
MULTI-PIXEL TO SUB-PIXEL TARGETS APPLIED TO AGA THERMOVISION IMAGERY

G.W. McQuistan

SUMMARY

Evaluation of a simple algorithm for estimating the infrared signature of small multi-pixel and sub-pixel targets in calibrated digital imagery is described. It is concluded that the only errors in the algorithm arise from the digitising process. The algorithm is simple and the target area does not have to be defined, nor does it have to be visible on the displayed imagery.

POSTAL ADDRESS: Director, Surveillance Research Laboratory,
PO Box 1650, Salisbury, South Australia 5108

TABLE OF CONTENTS

LIST OF TABLES

SRL-0020-TM

LIST OF FIGURES

1. INTRODUCTION

Infrared imaging systems can provide a means of measuring the infrared radiometric output of a target recorded in the image if a number of conditions are met. The imaging system must be capable of being calibrated, that is, for a given input there has to be a repeatable output and changes with system settings, such as gain and offset, must be traceable. Also to determine the target output or signature it is necessary to know how the radiation is modified by the atmospheric path between the object and the imaging system.

Infrared imagery is generally recorded as digital levels, that is, for one image or frame there are a set of signal values, one for each picture element (pixel) within the image. When a target is large and the image covers many pixels it seems intuitively correct that by comparing the signal levels with those obtained from a similar sized known target, a suitable calibration would be provided. However when the target is less than one pixel in size it is not obvious that the same large source is an adequate calibration.

Measurements have been made of the infrared radiation from a number of targets ranging in size from about 7 pixels to a small fraction of a pixel. This report describes the measurements, the algorithm used for the analysis and discusses the results. It is concluded that with this particular imaging system (AGA Thermovision) the algorithm can accurately measure the radiation from multi-pixel to sub-pixel targets.

2. SIGNATURE MEASUREMENT ALGORITHM

In an image each pixel has a given signal level which is obtained by digitising the analogue signal. This analogue signal can be obtained in different ways depending on whether the detecting system is a mosaic array of detectors, where each digital value corresponds to a pixel, or whether the system has a linear array or a single detector scanning across the image and successively producing pixel values. In all cases the detected signal is modified by the bandwidth limitations of the detecting and recording systems, and particularly the analogue to digital conversion system.

The pixels of a digitised image do not necessarily provide a one to one correspondence with a uniformly distributed grid of squares in object space. Not all detectors are square, nor do they have uniform sensitivity across their areas. Some of these effects are smoothed out by the point spread function of the sensing system which is generally larger than the detecting elements. Other effects, such as different spatial bandwidths in the vertical and horizontal directions of the image, must be corrected.

On the assumption that the pixel values represent the average value of the signal over an area (not necessarily square) corresponding to the area of the detector element, the algorithm is developed to measure the infrared signature of targets with a range of sizes from many pixels to a small fraction of a pixel.

Figure 1 (a) schematically illustrates a cross section of a signal recorded by the imaging system, one row of a number making up the image. The initial aim in determining the signature is to find the volume of the signal between the image signal levels and the background signal levels. This is commonly referred to as the apparent contrast signature. As an empirical measurement it is useful and it can be further reduced to a

variety of absolute signatures if other factors, such as target distance, size, aspect and atmospheric transmission are known. Hence the focus in this report is on the first step in the signature evaluation, the estimate of the volume between the target signal and the background signal.

As presented to the analyst the signals are in digital levels (DL) which bear a linear relation to some radiometric unit (eg watts cm^{-2} sr^{-1} μm^{-1}). The volume that must be determined is the integrated difference between the target and background digital levels. The difference in digital levels between target and background for any one pixel is indicated by dDL and when these are integrated over all the pixels of the target image the resulting volume is designated here by SdDL.

If the image is large, covering many pixels with the majority having large digital levels of contrast (dDL) above the background, there are many ways of estimating SdDL. However if the image is small and the contrast (dDL) low the target may not even be apparent when displayed. This algorithm is intended to make an accurate estimate for all types of target images. The basis of the algorithm is to define a box of pixels which contains, at least, all target pixels and to define a second box which contains only background pixels. Let the target box contain m pixels and the background box contain n pixels. Then the required enclosed volume SdDL is given by,

$$SdDL = (\Sigma DL)_T - (m/n) \times (\Sigma DL)_B \qquad (1)$$

where the summation is over the target and background boxes respectively.

This formula determines the average background digital level and subtracts it from all pixels in the target box. It should be noted that the target box can contain any number of background pixels and as their digital levels are automatically subtracted out they make no difference to the result. Therefore the extent of the actual target image need not be delineated which is important where faint targets are involved. Typical target and background boxes are shown in figure 2.

For the test experiments reported here target and background box selections have been made with the aid of displayed images. The selected target box must enclose all pixels of the target and where there is doubt about the edges of the target image a generous boundary of pixels should be included. It is useful to know the point spread function of the imaging system when defining the target box size.

The purpose of the background box is to determine the mean digital level of the background on which the target is imaged. The background may have noise and structure and care must be taken to eliminate these effects as much as possible. Sufficient numbers of pixels must be taken to average out the noise and this can be gauged by inspecting the respective means and standard deviations of the pixel values within the boxes. By surrounding the target box by the background box linear variations in the background can be minimised. It is general practice to separate target and background boxes by at least one pixel. The sizes of both target and background boxes may be increased until a consistent signature (SdDL) is obtained.

3. AGA THERMOVISION SYSTEM

Two AGA Thermovision systems were used to record test imagery, model 780 SW BBAR (3 to 5 μm) and model 780 LW (8 to 14 μm). To record AGA imagery two controls are available, Thermal Level (TL) and Thermal Range (TR) as illustrated in figure 1(b). Both these controls are set manually and recorded. Thermal Level is set near the centre of the range of Instrument Units (IU) of interest. The Thermal Range is set to cover the range of signals of interest within the whole image. The signal within the Thermal Range can be recorded as an analogue signal and subsequently digitised or directly digitised and passed to storage. The latter method was used for the experiments described herein. The signals are digitised to 8 bits (0 to 255) with 193 useable levels within the Thermal Range.

The system is calibrated against a range of black bodies with different temperatures to define a calibration curve of black body temperature vs the system output expressed as Instrument Units. With knowledge of the spectral response of the sensing system (sensor and optics) and the short atmospheric path used in the calibration, it is possible to calculate the effective power from the black body falling on to the detector. The IUs should be a linear function of the effective power.

The relationship between DL, TL, TR, and IU is as follows,

$$IU = TL + (DL - 127.5) \times TR/193 \qquad (2)$$

Thermal Level can be recorded only to an accuracy of about 0.5 units therefore where possible changing this level during an experiment is avoided. This was not possible for all of the present experiments (see Section 4).

4. EXPERIMENTS

A metal plate with four circular holes of different sizes, drilled completely through, was used as a target plate for the experiments. The target plate was placed in front of a heated flat black body plate to provide four targets of different angular sizes. The holes were at the four corners of a square of 128 mm sides, each hole being circular with measured diameters of 25.3 mm (A), 12.7 mm (B), 6.4 mm (C) and 3.2 mm (D), (see figure 3). Images were recorded at distances of 1, 2 and 4 m from the target plate, to give images of the holes ranging in size from about 7 to 0.2 pixels diameter. A summary of the recorded images is given in Table 1.

One set of images (I) was recorded with the LWB system at the three distances and a similar set (II) was recorded with the SWB system. The data from these sets was used to investigate the radiation from the larger holes and any major differences between the LWB and SWB systems. The heated plate temperature was set just below the level that saturated the largest image and the Thermal Range was set to provided a noticeable signal through the smallest hole. No significant differences were noted between the two systems and in subsequent sets only the SWB system was used.

A series of five images (Set III) was recorded at a distance of four metres, firstly to provide data on the four smallest targets and secondly to investigate whether small movements of the images across the focal plane had any effect on the results.

The final set (IV) of images was recorded to measure accurately the radiation through the two smallest holes. For the first and second images of the set the plate temperature, Thermal Level and Thermal Range were set to give good dynamic range on hole A, while in the third image the controls were set for hole C allowing images of holes A and B to saturate.

To determine the source radiation from the heated plate, the target plate was removed and an image of the heated plate was recorded. In general this determination of the source radiation was made before and after each target image was recorded. The exception to this was in the first set (I) where the source radiation was measured only after the target image was recorded. Also for this first set of images only the average radiation over the whole plate was measured, whereas in the subsequent sets the radiation was measured for each area of the heated plate directly behind each target hole. It was not possible to maintain the heated plate at a constant temperature and therefore the series of source measurements were used to interpolate values for the times of recording of each set of images as this provided a nearly linear change of the output with time.

Two practical limitations were encounted in the conduct of the experiments. The range of hole sizes was such as to make it impossible to get a signal of sufficient magnitude, for accurate measurement, through the four holes simultaneously. This meant that for one set of images using different distances the AGA settings had to be altered for each distance. Also to get sufficient radiation through the smaller holes the temperature of the heated plate had to be raised to such a level that it was impossible to measure the source radiation without altering the Thermal Level. As stated earlier, adjustment of the Thermal Level may introduce additional errors of about 0.5 IUs/pixel, but this could not be avoided in the Set IV measurements.

5. ANALYSIS AND RESULTS

5.1 Analysis procedure

Equation (2) of Section 3 describes the relationship between the Instrument Units (IU) and the Digital Level (DL) in terms of the selectable control parameters of the AGA Thermovision. For the analysis, rather than use IUs it was decided to use DLs and specifically those corresponding to the control parameters of the target image. Thus for each target image the DLs in the analysis are those that were actually measured. To calculate the radiation through each hole the DLs of the source plate were measured and converted to effective DLs of the target image parameters using equation (2) assuming the IUs were invariant under this conversion. This results in the effective DLs of the source radiation generally exceeding 224. This conversion process is detailed in figure 4. Tests involving measurement of the DLs using various Thermal Ranges showed that consistent values of IUs were obtained. On varying Thermal Level the LWB system also provided consistent results but the SWB system was consistently in error by about 4% when the Thermal Level was changed over the range equivalent to 20° to 100°C. An investigation of the original calibration of the SWB system involving

calculation of the effective power falling on the detector from each calibration blackbody indicated
the same 4% error. This points to a problem in the calibration procedures which are being reviewed.
Data from this investigation were used to correct the results from those images (only Set IV) where
Thermal Levels of high values had to be used.

5.1.1 Source images

For each source (heated plate) image the average value of the DLs was determined over the area
behind each of the four holes and then converted to the corresponding DL appropriate to the
target image parameters as described above. From this average DL value of the source the
background DL value of the target image, appropriate to the hole, was subtracted and the
difference multiplied by the area of the hole (in pixels, see Section 5.1.3) to give the calculated
value of SdDL.

5.1.2 Target images

The algorithm (Section 2) was applied to each of the four images of the four holes on each of the
recorded images. Target and background boxes were defined and the integration and subtraction
performed as in equation (1) to give the measured values of SdDL.

The image scales for each target image were determined as follows. The centre of the images of
each of the holes was found by quadratic interpolation of the DLs in the horizontal and vertical
directions and using the known distance between the hole centres in object space the image scales
(pixels/mm) in horizontal and vertical directions, were determined. From this and the known hole
diameter (mm), the hole diameter in pixels was obtained. The horizontal hole sizes are given in
Tables 2 to 5.

Tables 2 to 5 give the measured and calculated values of SdDL together with the differences and
percentage error for each hole image of the four sets of images recorded.

5.1.3 Area factor

The AGA Thermovision is an interlacing scanner providing a frame of data pixels made up of four
interlaced fields, each field being displaced vertically by a quarter of the field line spacing. For
these experiments only one data field was used. This provided an image of 64 rows with 128 pixels
in each row. The pixel scale of the image is therefore not the same in the vertical and horizontal
directions and this difference must be corrected for in the signature analysis of finite size objects.
The images scales, the relation between pixels in the image space and distance in object space were
used for this correction (see Section 5.1.2). The ratio of the horizontal to vertical image scales, the
area factor, was determined for all images recorded and was found to have an average value of
1.72. This area factor was applied in determining the area of each hole in image space, the area
being,

$$\frac{\pi}{4} \cdot \frac{d^2}{1.72} \qquad (\text{pixels})^2$$

where d is the diameter of the hole in the horizontal direction. This area is used in finding the calculated value of SdDL (Section 5.1.1).

5.2 Point spread function

Because knowledge of the point spread function of the imaging system is important when using the algorithm this function was estimated here for the SWB AGA system. The point spread function provides a guide to the minimum size of the target box required and allows estimates to be made of the errors.

The image of the smallest hole (0.21 pixels diameter) of image SWB 17 was used to make the estimation of the point spread function. The image had a maximum contrast above the background of 17 digital levels. Noise was just apparent in the background (about 1 DL) but there was considerable trend in the background in both the horizontal and vertical directions. Using the surrounding background box digital levels a two dimensional interpolation was used to provide background digital levels for each pixel in the target box. These were subtracted from the image digital levels for the respective pixels to give a contrast image. The centre of this image was determined by quadratic interpolation in the horizontal and vertical directions and interpolated image contrast levels were determined for a number of unit pixel distances from the centre in both directions. These are plotted in figure 6. The lefthand side of the figure gives the normalised values for the horizontal direction and righthand side gives the values in the vertical direction together with a curve where the pixels units have been multiplied by 1.72 to correct for the different image scale in that direction.

The figure shows that for a point size target (say less than half a pixel in size), to obtain a dynamic range accuracy of 2% the target box should be at least four pixels diameter in the horizontal direction and three in the vertical direction. Application to non-point source targets is obvious.

5.3 Errors in application of the algorithm

The percentage error in estimating the signature (SdDL) is plotted in figure 5 where the minimum and maximum value of the percentage error is given as a function of SdDL.

Errors can arise in applying the algorithm due to difficulty in accurately assessing the background digital level surrounding the target, background noise and the digitising process.

In the experiments reported here the backgrounds were either of uniform digital level or varied linearly in two spatial directions. Therefore it was possible by completely or nearly surrounding the target box with background pixels to obtain an accurate average background level. In images where the background is more structured, for example with clouds and cloud edges, the background level may not be able to be accurately determined.

The background noise or clutter was less than two DLs standard deviation for all images and for the majority of images it was less than one DL. When noise is present inspection of the background box pixel statistics will indicate the magnitude of the noise and hence the effect on the resulting signature.

The digitising process introduces an error to the algorithm that has a non-linear component. It is obvious that the error of digitising (maximum one digital level) is reduced when a large number of pixel levels that cover a large range of values are added together. That is, the sum of the digital levels in the target box (SDL) is generally not subject to large digitising errors. However to obtain the difference (SdDL) the background level must be subtracted from each target level. Because the background level is relatively uniform the average value will retain a constant digitising error no matter how many individual values make up the average. The algorithm has the property that all background pixels in the target box are cancelled by the subtraction process, therefore only the pixels in the target box which contain the target contribute to this digitising error.

The number of pixels which contain target signal depends upon the object size, the point spread function of the imaging system and the difference in digital level between the peak target signal and the background (the digital level contrast).

Because the number of availab': images is small it is not possible to investigate these factors statistically. Therefore the error which arises from digitising the background was estimated for the range of hole sizes used and the target image contrasts. The number of target pixels in the image was estimated using the point spread function and the hole diameter (pixels). Three contrast levels (50, 20 and 10) were used, the digital level contrast being a major factor in the apparent area of the image. SdDL was also calculated for these model images together with the percentage error in SdDL determined as 0.5 times the area of the image divided by SdDL. Here it is assumed that the digitising error can vary from 1 to 0.0 levels per pixel and the mean value (0.5) has been used.

The results of the above calculations are shown in figure 7 (dotted curves). These estimated digitising errors are the means that would be obtained from a large sample of images with the maximum error being twice the mean. The measured percentage errors from the images (with SdDL greater than 50) of the largest and smallest holes are also plotted on figure 7 with the appropriate calculated contrast level shown by the full sections of the curves.

5.4 Image movement across the focal plane

Set III of the recorded images were made with the purpose of investigating possible changes in the total signal from the holes as calculated by the algorithm when the image moves across the focal plane. After image SWB 2 had been recorded the image plate was moved slightly (actually rotated about one corner) and then SWB 3 was recorded. The movement was repeated always in the same direction until following the recording of SWB 5 the plate was moved back to its initial position and SWB 6 recorded. Analysis of the hole positions of these images indicated that the maximum movement of the hole images was about $\frac{1}{4}$ pixel.

The algorithm results (Table 4) show no significant change in percentage error associated with this movement of the images.

6. DISCUSSION

The measured errors of the algorithm, summarised in figure 5 show that the errors are strongly dependent on the total signal detected. Ignoring the source of the errors for the movement, figure 5 provides a good guide to the errors that may be expected from the algorithm. For example, if a measurement with an accuracy of 10% is required then the total signal (SdDL) must be greater than 50. This applies to small, near pixel sized targets, not to extended area low contrast targets.

Estimated errors in the digitising process, given in figure 7, indicate that the total error in the measurements can be completely accounted for by this process. There is no indication of significant error related to the target size for the range of target images from 7 to 0.2 pixels.

When the images are moved small distances across the focal plane (Section 5.4) no significant change to the output of the algorithm was observed. This was to be expected as the multi-pixel size of the point spread function has a good averaging effect. The point spread function indicates that approximately 1/3 of the radiation from a point source would fall in the central pixel. For many other infrared imaging system the corresponding fraction would be in the range of 1/2 to 2/3 which would indicate the need to test higher resolution systems for output variability as small targets are moved across pixels.

In this paper the algorithm accuracy has been discussed in units of digital levels. In most applications the requirement is to determine an absolute measure in radiance or temperature and the errors in these measures, resulting from algorithm errors, will depend upon the instrument parameters in use (TL and TR). Equation (2) gives the relationship between the absolute measure (IU) and the digital level. Referring back to figure 1, the algorithm determines the 'volume' of the signal above the background level, and the percentage error in the determination of this volume will be larger than the percentage error above the base or absolute level. Errors, other than those arising from the algorithm, will be present but are not discussed here.

7. CONCLUSION

An algorithm is described for the measurement of the infrared signature of small targets recorded in calibrated imagery. By comparing the results of the algorithm with the calculated signatures it is shown that the algorithm provides consistent results over a range of hole sizes from 7 to 0.2 pixels diameter.

The algorithm is easy to apply, the image of the target does not have to be defined (ie outlined) and does not have to be visible on a display screen.

Percentage error is estimated from the measurement of 48 target images as a function of hole size.

The magnitude of the errors are consistent with that arising from the digitising process which indicates this is the major source of error.

Positioning of the images with respect to the pixel centres does not make a significant difference to the measured signature.

The two imagers used to evaluate the algorithm were a long waveband and short waveband AGA Thermovision 780. These instruments are of the single detector scanning type but it is considered that the results would also apply to multi-pixel scanners and focal plane arrays. Performance parameters, particularly the point spread function may be quite different from one brand of equipment to another and testing as has been described would be adviseable.

TABLE 1. SUMMARY OF RECORDED IMAGES

Image Set	AGA	Image No	Distance (m)	Calibration
I	LWB	2 4 6	1 2 4	Used average temperature of whole plate measured after recording each image. Constant TR.
II	SWB	7 13 11	1 2 4	Before and after each image recorded. Constant TR.
III	SWB	2 3 4 5 6	4 4 4 4 4	Before and after each image recorded. Constant TL.
IV	SWB	9 13A 17	4 4 4	Before and after each image recorded. Constant TR.

TABLE 2.   SUMMARY OF LWB AGA MEASUREMENTS (IMAGES 2,4, AND 6)

Hole diameter (pixels)		6.4	3.1	1.5	0.78	0.38	0.19
Image No.		Measured value - integral of (signal (DL) - background (DL) over image)					
	Measured	1973.72	459.85	119.33	29.00		
	Calculated	1962.42	481.24	121.50	31.62		
	Difference	+11.30	-21.39	-2.17	-2.62		
LWB 2	%Error	+0.6	-4.4	-1.8	-8.3		
	Measured		390.00	92.00	21.18	9.75	
	Calculated		400.59	98.56	25.43	6.33	
	Difference		-10.59	-6.56	-4.25	+3.42	
LWB 4	%Error		-2.6	-6.7	-17.7	+54.0	
	Measured			72.67	17.75	2.75	0.00
	Calculated			79.05	19.24	5.05	1.25
	Difference			-6.38	-1.49	-2.30	-
LWB 6	%Error			-8.1	-7.7	-45.5	-

Source calibrated by averaging over the whole plate after each image recorded

TABLE 3. SUMMARY OF SWB AGA MEASUREMENTS (IMAGES 7, 11 AND 13)

Hole diameter (pixels)		7.3	3.5	1.8	0.88	0.43	0.21
Image No.		Measured value - integral of (signal (DL) - background (DL) over image)					
	Measured	6393.20	1608.20	398.50	106.00		
SWB 7	Calculated	6371.22	1614.16	409.92	102.85		
	Difference	+21.98	-5.96	-11.42	+3.15		
	%Error	-0.3	-0.4	-2.8	+3.1		
	Measured		1148.36	292.50	70.00	23.00	
SWB 13	Calculated		1166.44	298.40	74.46	19.02	
	Difference		-18.08	-5.90	-4.96	+3.98	
	%Error		-1.6	-2.0	-6.0	+20.9	
	Measured			267.67	69.00	14.00	-2.85
SWB 11	Calculated			278.85	71.64	18.08	+4.53
	Difference			-11.18	-2.64	-4.08	-
	%Error			-4.4	-3.7	-22.6	

Source calibrated before and after each image recorded. Constant Thermal Range (TR) used

TABLE 4. SUMMARY OF SWB AGA MEASUREMENTS (IMAGES 2 TO 6)

Hole diameter (pixels)		1.71	0.86	0.42	0.22
	Measured	259.50	63.00	18.00	4.00
SWB 2	Calculated	259.82	63.97	16.25	4.19
	Difference	-0.32	-0.97	+1.75	-0.19
	%Error	0.0	-0.2	+10.8	-4.5
	Measured	258.50	66.50	18.00	3.50
SWB 3	Calculated	257.42	62.58	16.07	4.02
	Difference	+1.08	+3.92	+1.93	-0.52
	%Error	0.0	+6.3	12.0	-12.9
	Measured	260.50	62.00	12.00	5.00
SWB 4	Calculated	254.36	61.72	15.89	4.08
	Difference	+6.14	+0.28	-3.89	+0.92
	%Error	+2.4	+0.1	-24.5	+22.5
	Measured	255.00	54.00	15.00	3.00
SWB 5	Calculated	251.42	61.56	15.49	4.02
	Difference	+3.58	-7.56	-0.49	-1.02
	%Error	+1.4	-12.3	-3.2	-25.4
	Measured	257.00	56.00	14.00	7.00
SWB 6	Calculated	248.13	59.72	15.58	3.96
	Difference	+8.87	-3.72	-1.58	+3.04
	%Error	+3.6	-6.2	-10.1	-76.8

Source calibrated before and after each image recorded. Constant Thermal Level (TL) used

TABLE 5.   SUMMARY OF SWB AGA MEASUREMENTS (IMAGES 9, 13A AND 17)

Hole diameter (pixels)		1.69	0.85	0.43	0.21
Image No.	Measured value - integral of (signal (DL) - background (DL) over image)				
	Measured	241.33	61.00	15.50	-0.50
SWB 9	Calculated	259.67	63.02	16.15	4.14
	Difference	-18.34	-2.03	-0.65	-
	%Error	-7.1	+3.2	-4.0	-
	Measured	1274.70	325.00	76.67	12.00
SWB 13A	Calculated	1272.72	320.90	82.29	20.20
	Difference	+1.98	+4.10	-5.62	-8.20
	%Error	+0.2	+1.3	-6.8	-40.6
	Measured			253.00	63.76
SWB 17	Calculated			268.73	70.70
	Difference			-15.73	-6.94
	%Error			-5.9	-9.8

Source calibrated before and after each image recorded. Constant Thermal Range (TR) used throughout

(a) Algorithm parameters   (b)   AGA thermovision parameters
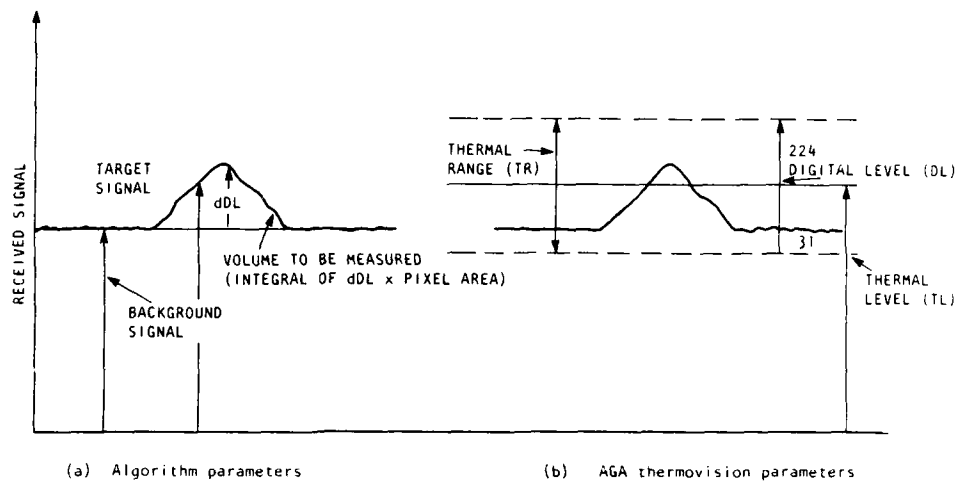
Figure 1. Schematic cross-section of an image

MULTIPLE TARGETS

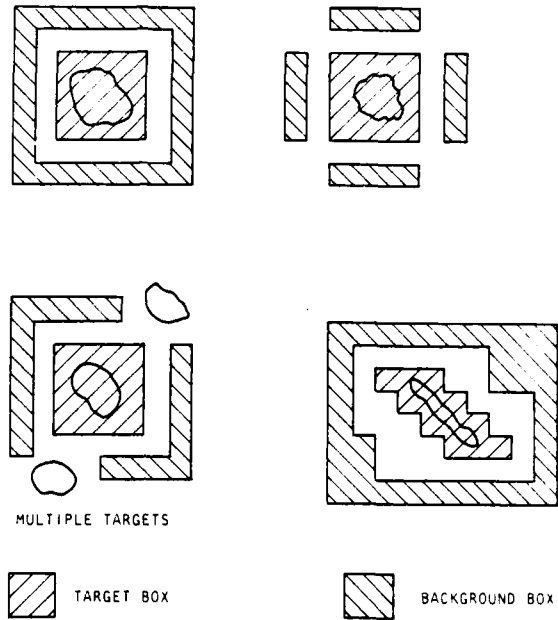TARGET BOX   BACKGROUND BOX

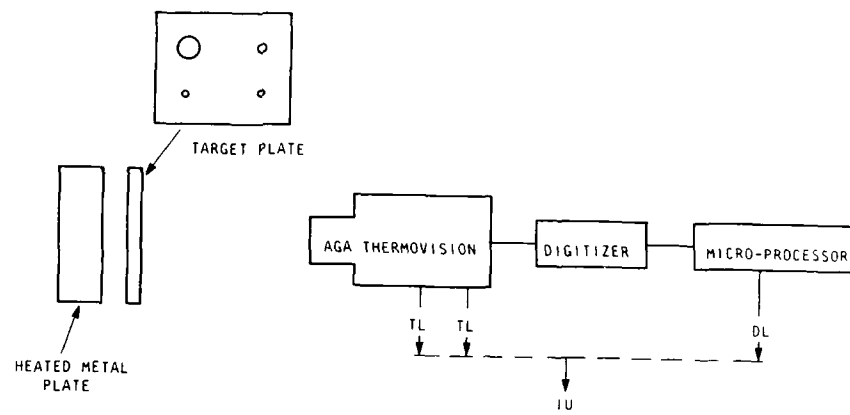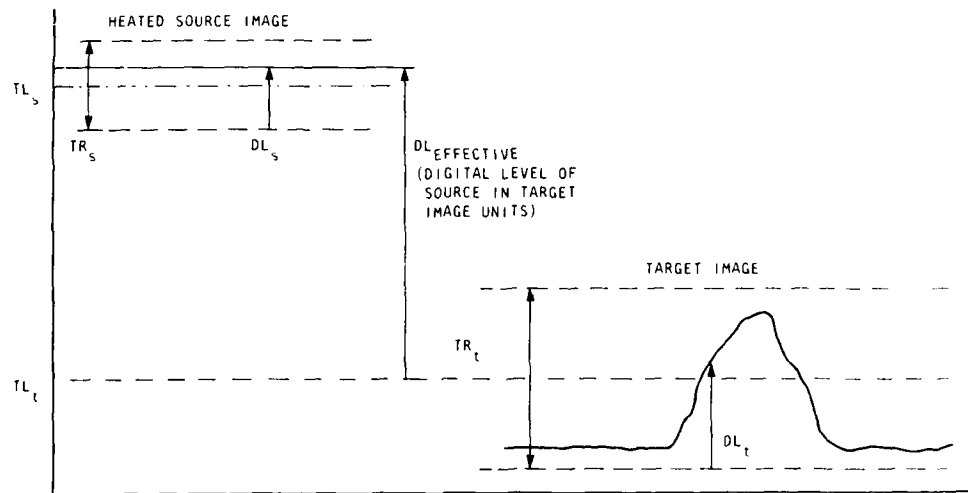Figure 2. Examples of target and background boxes

Figure 3. Experimental arrangement

$$IU_{Source} = TL_s + (DL_s - 127.5)TR_s/193 = TL_t + (DL_{Effective} - 127.5)TR_t/193$$

$$\text{thus} \qquad DL_{Effective} = [193(TL_s - TL_t) + 127.5(TR_t - TR_s) + TR_s \cdot DL_s]/TR_t$$

Figure 4. Conversion of source image DL to target image DL
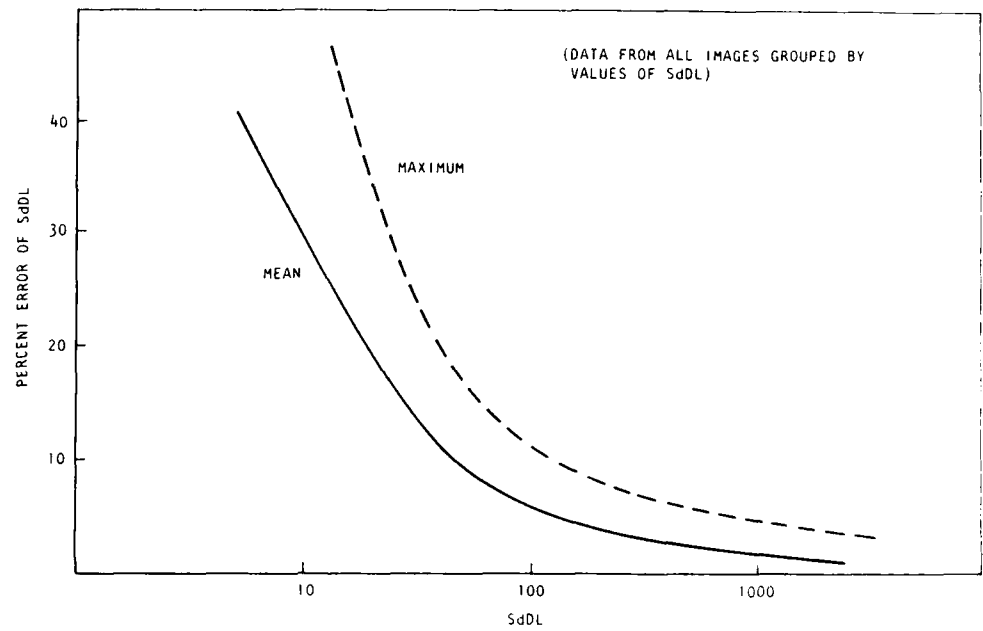
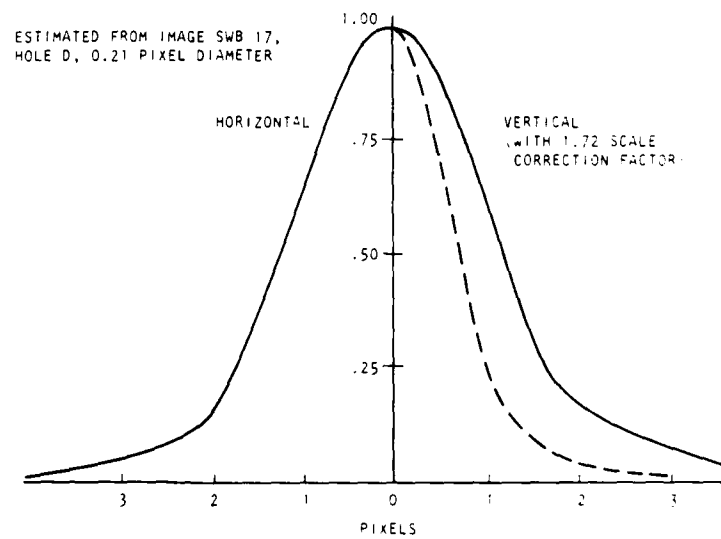Figure 5. Mean and maximum values of absolute percentage error as a function of SdDL

ESTIMATED FROM IMAGE SWB 17,
HOLE D, 0.21 PIXEL DIAMETER

HORIZONTAL

VERTICAL
(WITH 1.72 SCALE
CORRECTION FACTOR)

1.00

.75

.50

.25

3   2   1   0   1   2   3
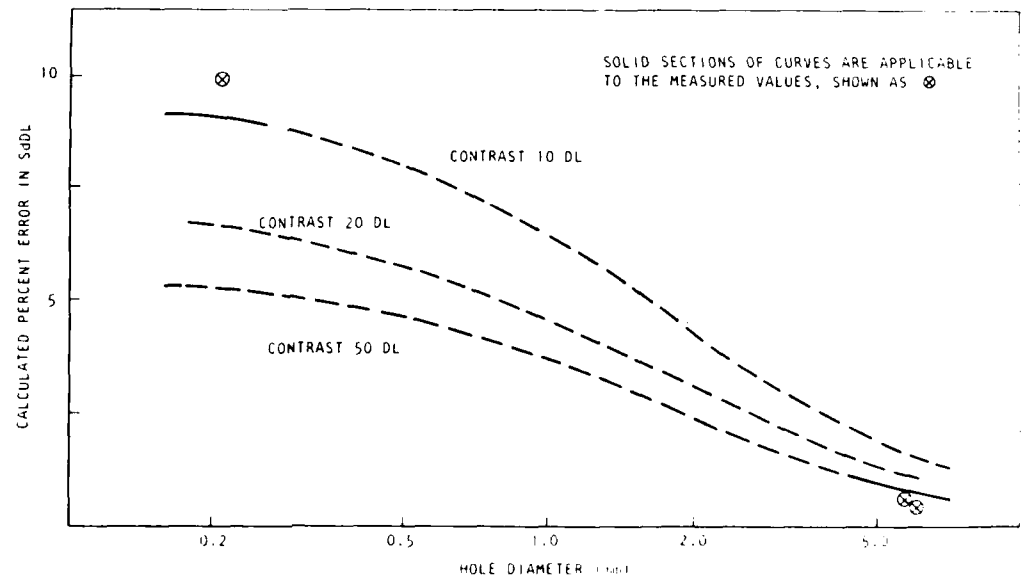
PIXELS

Figure 6. Normalised point spread function

Figure 7. Calculated percentage digitising error in SdDL as a function of hold size and digital level contrast

DISTRIBUTION

No. of copies

DEPARTMENT OF DEFENCE

Defence Science and Technology Organisation

Chief Defence Scientist

First Assistant Secretary Science Policy } 1

First Assistant Secretary Science Corporate Management

Counsellor, Defence Science, London — Cnt Sht Only

Counsellor, Defence Science, Washington — Cnt Sht Only

Surveillance Research Laboratory

Director, Surveillance Research Laboratory — 1

Chief, Optoelectronics Division — 1

Research Leader, Systems and Image Analysis — 1

Research Leader, Surveillance Devices — 1

Head, Image Analysis — 1

Head, Systems Analysis — 1

Head, Optoelectronics Warfare — 1

D.W. Faulkner, Optoelectronics Division — 1

K.C. Liddiard, Optoelectronics Division — 1

B.W. Rice, Optoelectronics Division — 1

T. Adams, Optoelectronics Division — 1

Electronics Research Laboratory

Director, Electronics Research Laboratory	1
R. Oerman, IR and Optical Countermeasures	1
O. Scott, IR and Optical Countermeasures	1

Navy Office

Navy Scientific Adviser	Cnt Sht Only

Army Office

Scientific Adviser - Army	1

Air Office

Air Force Scientific Adviser	1

Joint Intelligence Organisation (DSTI)	1

Libraries and Information Services

Librarian, Technical Reports Centre, Defence Central Library, Campbell Park	1

Document Exchange Centre
Defence Information Services Branch for:

Microfiche copying	1
United Kingdom, Defence Research Information Centre	2
United States, Defense Technical Information Center	12
Canada, Director, Scientific Information Services	1
New Zealand, Ministry of Defence	1
National Library of Australia	1

Main Library, Defence Science and Technology Organisation Salisbury	2

SRL-0020-TM

Library, Aeronautical Research Laboratories	1
Library, Materials Research Laboratories	1
Librarian, DSD, Melbourne	1
UNITED KINGDOM	
Document Supply Centre, UK	1
Institution of Electrical Engineers, UK	1
UNITED STATES OF AMERICA	
Engineering Societies Library, USA	1
Author	2
Spares	4
Total No. of copies	51

DOCUMENT CONTROL DATA SHEET

Security classification of this page : | UNCLASSIFIED

1 DOCUMENT NUMBERS	2 SECURITY CLASSIFICATION
AR Number : AR-005-450	a. Complete Document : Unclassified
	b. Title in Isolation : Unclassified
Series Number : SRL-0020-TM	c. Summary in Isolation : Unclassified
Other Numbers :	3 DOWNGRADING / DELIMITING INSTRUCTIONS

4 TITLE	EVALUATION OF A SIMPLE ALGORITHM FOR ESTIMATING INFRARED SIGNATURES FROM MULTI-PIXEL TO SUB-PIXEL TARGETS APPLIED TO AGA THERMOVISION IMAGERY

5 PERSONAL AUTHOR (S)	6 DOCUMENT DATE
G.W. McQuistan	May 1989
	7 7.1 TOTAL NUMBER OF PAGES 21
	7.2 NUMBER OF REFERENCES –

8 8.1 CORPORATE AUTHOR (S)	9 REFERENCE NUMBERS
Surveillance Research Laboratory	a. Task : 83/0+5
	b. Sponsoring Agency :
8.2 DOCUMENT SERIES and NUMBER Technical Memorandum 0020	10 COST CODE 643045

11 IMPRINT (Publishing organisation)	12 COMPUTER PROGRAM (S) (Title (s) and language (s))
Defence Science and Technology Organisation	

13 RELEASE LIMITATIONS (of the document)
Approved for Public Release

Security classification of this page : | UNCLASSIFIED

Security classification of this page : | UNCLASSIFIED |

14 ANNOUNCEMENT LIMITATIONS (of the information on these pages)

No limitation

---

15 DESCRIPTORS		**16 COSATI CODES**
a. EJC Thesaurus Terms	Infrared signatures Algorithms Infrared images	0063C
b. Non - Thesaurus Terms		

---

17 SUMMARY OR ABSTRACT
   (if this is security classified, the announcement of this report will be similarly classified)

Evaluation of a simple algorithm for estimating the infrared signatures
of small multi-pixel and sub-pixel targets in calibrated digital
imagery is described. It is concluded that the only errors in the
algorithm arise from the digitising process. The algorithm is simple
and the target area does not have to be defined, nor does it have to
be visible on the displayed imagery.

Security classification of this page : | UNCLASSIFIED |